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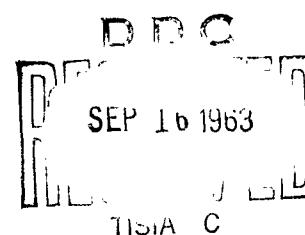
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ENGINEERING RESEARCH - BRAZING
ALLOY - "DYNABRAZE B" -
COMPOSITION OPTIMIZATION OF -



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GENERAL DYNAMICS | FORT WORTH

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ENGINEERING RESEARCH - BRAZING ALLOY - "DYNABRAZE B" -
COMPOSITION OPTIMIZATION OF -

W. M. PRATT

6 DECEMBER 1962

ENGINEERING DEPARTMENT

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GENERAL DYNAMICS | FORT WORTH

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ENGINEERING RESEARCH - BRAZING ALLOY - "DYNABRAZE B" -
COMPOSITION OPTIMIZATION OF -

I. SUMMARY

The object of this test was to establish the optimum manganese content in "Dynabraise B" brazing alloy (95% silver - 5% aluminum + manganese) to develop the best combination of crevice corrosion resistance, lap shear strength and brazeability. Brazing alloys were made with manganese additions of .1, .2, .3, .5 and 1.0% from a master alloy of 95 silver - 5 aluminum. Lap shear, corrosion and metallographic specimens were made from RS 140 titanium brazed with the various alloys.

The range of manganese content from .5 to 1.0% definitely appears to be the best of the groups studied, judging from the results of the corrosion tests and metallographic studies. Strength values as determined by the lap shear testing were indeterminate in direct comparison, due to the wide range of values obtained for each group. However, the shear strength values, when coupled with the results of the metallographic studies definitely indicates superiority in the manganese content of 1.0%

II. LIST OF FIGURES

Figure 1 on page 11 shows the salt spray flexure test specimens. Photomicrographs of C. P. (commercially pure) titanium core brazed to RS 140 titanium skin with the brazing alloy compositions under study are shown in the following list of figures.

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IV. INTRODUCTION

The 95% silver - 5% aluminum braze alloy was developed under an Air Force Contract, AF33(600)-34392 by General Dynamics/Fort Worth. The alloy was developed for brazing titanium honeycomb sandwich panels. With a pressing need for the alloy at the time, accurate determinations were not made to establish the optimum manganese content. Numerous small shipments from two major brazing alloy producers were received with variations in manganese content. These variations in composition required adjustment in brazing temperature and produced variations in joint qualities. The contract was terminated before its completion and optimization studies for composition were not conducted.

This report describes an investigation performed to establish the brazing alloy composition in order to develop its best properties and thereby enhance its usage.

V. PROCEDURE

A 300 gram master alloy of 95 silver - 5 aluminum was made by melting together 999+ silver and 2S C. P. aluminum foil. The metals were induction melted in a graphite crucible under argon. While molten, the crucible was gently agitated to improve mixing of the metals. After cooling, the alloy button was flattened in a hydraulic testing machine, sectioned into four parts, and remelted as above. This procedure was repeated, the purpose being to assure uniformity in the finished alloy.

Twenty to twenty-five gram lots of the above master alloy were mixed with proportionate amounts of electrolytic manganese chips, 99.9+% purity, and melted in an identical manner as the master alloy described in the previous paragraph. All of the alloys were reduced to filings with a clean file.

Titanium specimens to be brazed were cleaned by immersing in a 15% nitric acid - 3% hydrofluoric acid solution at room temperature for 30 seconds, rinsing in tap water and drying. Brazing was accomplished in an electrically heated tube furnace equipped with a protective argon atmosphere. The argon was dehydrated by passing it through a tube coil immersed in acetone and dry ice at -100°F. The argon was further purified by passage over hot titanium chips within a retort. Brazing temperatures were monitored with a chromel-alumel thermocouple attached to the specimen holder. All of the specimens were brazed at 1650°F for 5 minutes.

Lap Shear Tests

Two pieces of .052" thickness RS 140 titanium, 4-1/2" x 1", were wired together with a 3/16" overlap and brazed. Three sets were brazed for each of the six braze alloys. After brazing, the strips were cut into 3/4" wide specimens to form individual lap shear specimens, 3/4" x 1-13/16". Shear values were determined by compressively loading the edges of the specimens in a jig which held the

specimens vertical and prevented bending moments. The tests were conducted in a Baldwin Universal Test Machine of 5000 pounds capacity. Loading rate was 1000 pounds per minute.

Salt Spray Corrosion Flexure Tests

Corrosion specimens were made by brazing a 1" x 1" x 1/2" piece of C. P. titanium core to the center of a 1" x 4" x .010" strip of RS 140 titanium. The brazed specimens were bent over a 5 inch diameter mandrel as an indication of the soundness of the braze. The relatively inflexible titanium core, brazed to the flexible .010" titanium skin, snapped apart at the braze interface when weakly brazed. Basically, this test was a form of a peel test. Specimens which did not fail were exposed to salt spray for 8 hours and again tested by bending over the mandrel. Failure from flexure resulted from separation of the core-skin joint which had been weakened by crevice corrosion. Those specimens which did not fail were exposed to 8 additional hours of salt spray and flexure tested. The flexure test was then repeated after 16 hours of salt spray exposure. An 8 hour - 16 hour cycle of salt spray corrosion-flexure testing was continued to failure or until a total of 500 hours exposure without failure was obtained. Salt spray exposure was conducted in a standard salt spray cabinet made by Universal Pump and Filter Company. Test procedures conformed to the standards established by Federal Test Method Standard 151, Method 811 (20% salt spray).

Metallographic Studies

Specimens for metallographic examination were made by brazing a 1" x 1" x 1/2" C. P. titanium core section to a slightly larger piece of .010" RS 140 titanium. Standard metallographic techniques were exercised in the mounting, polishing, and etching of the specimens.

VI. RESULTS AND DISCUSSION

The master braze alloy was chemically analyzed for aluminum content and found to contain 5.12% Al. The balance of the alloy was assumed to be silver plus trace elements contained in the original alloying elements. An analysis of the experimental braze alloys having manganese additions yielded the following results:

<u>Manganese, % by Weight</u>	
<u>Nominal</u>	<u>Actual</u>
0.1	0.09
0.2	0.16
0.3	0.29
0.5	0.43
1.0	0.92

The actual manganese contents were quite close to the desired levels.

Lap Shear Results

The results of the single lap shear tests, given in Table I, indicate that the manganese addition reduced the average shear strength of the brazed joints. The 0.1% Mn addition was the most detrimental, reducing the average shear strength by 24%. The effect of the 0.2, 0.3, and 0.5% Mn additions were almost identical to one another in

so far as strength was concerned. Of the five levels of manganese investigated, 1.0% Mn had the least deleterious effect on shear strength. However, with the exception of the 0.1% Mn addition, the lap shear results were rather indeterminate due to the wide range of values for each braze alloy. It would be difficult to select a composition based on these results alone. Visual examination of the sheared joint faces of all failed specimens did not reveal any joints which were not completely brazed.

Corrosion Results

The salt spray corrosion flexure test results definitely indicate that specimens brazed with the alloy containing .5 to 1.0% manganese show the best resistance to this type of corrosion. The .3% Mn alloy was a borderline case in that one specimen failed after 464 hours while the other specimen did not fail in 500 hours of testing. The condition of the specimens after having been exposed to the salt spray corrosion may be seen in Figure 1. Results are given in Table II.

Metallographic Results

Photomicrographs of honeycomb sandwich specimen brazed with the various alloys are shown in Figures 2 through 5. As shown by the photomicrographs, increasing the manganese content of the brazing alloy from 0 to 1.0% improves the formation of fillets. Wetting of the base metal by the braze alloy was excellent in every case. Specimens brazed

with 95 silver-5 aluminum without manganese attacked the C. P. titanium core excessively. The addition of as little as .1% manganese reduces this reaction. As can be seen in Figures 5 and 6, the 0.5 and 1.0% brazing alloys have formed an additional diffusion layer in the C. P. titanium core. This diffusion layer apparently did not affect the salt spray corrosion flexure results but should be further evaluated by testing samples of brazed sandwich, particularly column compression tests.

VII. CONCLUSION

Considering all the brazing alloys investigated, the 95 silver-5 aluminum + 1.0 manganese had the best lap shear strength, salt spray corrosion flexure strength, and fillet forming characteristics.

VIII. RECOMMENDATIONS

On the basis of the tests conducted in this investigation, it is recommended that the optimum manganese content of the 95 silver-5 aluminum braze alloys system be 1.0%. Further tests should be conducted to:

- (1) examine effect of manganese contents between .5 to 1.0%
- (2) determine the effect of this braze alloy composition on the strength of brazed titanium honeycomb sandwich panels.

TABLE I - Log Shear Test Results - Branched TABULATION SHEET

Bragg A/10 Y	Specimen No.	Test No.	A.S.I.	Specimen No.	Test No.	A.S.I.	
95% Ag-5% Al + B-1	1497	2745	18.3	95% Ag-5% Al + B-1	0-1	1601 3205 20.0	
-2	1496	3665	24.5	44.0		-2 1601 3295 24.3	
-3	1679	2870	17.1			-3 1442 3490 24.2	
-4	1629	3130	19.2			-4 172 2750 18.3	
-5	1657	4420	26.7			-5 1500 3845 25.6	
-6	1408	3675	26.1			-6 1604 2890 18.0	
-7	1425	3880	27.2			-7 1642 3470 21.1	
-8	1493	4300	28.8			-8 1511 2585 17.7	
Age.		23.5				-10 1453 2695 18.5	
						-11 1542 3075 19.9	
95% Ag-5% Al + B-1	1493	1960	13.2	Age.		20.7	
1/2 Adm.	-2	1644	2055	12.3			
	-3	1531	3545	23.2	95% Ag-5% Al + B-1	E-1	1862 3170 17.0
	-4	1614	3990	24.1	+ 5% Adm.	-2	1789 4030 22.5
	-5	1469	2935	19.3		-3 1579 2665 16.9	
	-6	1520	2360	16.8		-4 1894 4475 22.0	
	-7	1525	1935	12.1		-5 1684 3215 19.1	
	-8	1628	2870	17.6		-6 1682 3775 22.4	
	-10	1612	2413	15.0		-7 1496 3523 23.9	
	-11	1523	3875	24.3		-8 1677 3330 19.9	
Age.		17.8				20.4	
95% Ag-5% Al + C-1	1571	3220	20.5	Age.			
1/2 Adm.	-2	1513	3150	20.8	95% Ag-5% Al + C-1	1512 3565 23.6	
	-3	1469	3725	25.4		-2 1414 3290 23.3	
	-4	1496	2860	22.0		-3 1709 3860 22.6	
	-5	1473	2775	18.8		-4 1564 3320 21.2	
	-6	1453	2250	22.6		-5 1462 3180 21.8	
	-7	1563	2575	16.5		-6 1582 3565 22.5	
	-8	1369	2760	20.3		-7 1421 3175 21.7	
	-10	1408	2470	16.1		-8 1535 3490 22.7	
	-11	1573	2735	17.2		-10 1671 3755 20.1	
Age.						-11 1571 3525 22.3	
						22.7	

TABLE IIRESULTS OF SALT SPRAY CORROSION FLEXURE TESTS

C. P. titanium honeycomb core brazed to .010" RS 140 titanium sheet tested by periodically flexing specimen over 5" dia. mandrel after exposure to 20% salt spray exposure.

<u>Braze Alloy</u>	<u>Spec. No.</u>	<u>Exposure Time</u>
95 Ag-5 Al	A-1	Failed before exposure
	A-2	Failed after 314 hours exposure
+.1% Mn.	B-1	Failed before exposure
	B-2	Failed after 290 hours exposure
+.2% Mn.	C-1	No failure after 500 hours exposure
	C-2	Failed after 290 hours exposure
+.3% Mn.	D-1	No failure after 500 hours exposure
	D-2	Failed after 464 hours exposure
+.5% Mn.	E-1	No failure after 500 hours exposure
	E-2	No failure after 500 hours exposure
+1.0% Mn.	S-1	No failure after 500 hours exposure
	S-2	No failure after 500 hours exposure



SPRAY CORROSION
ALUMINUM HONEYCOMB COUPON
ALUMINUM SKIN WITH 95AG-5AL

FIGURE 1



250X

Etch: 10% HNO₃ + 1% HF.

FIGURE 2.

Q. P. titanium core brazed to RS 140 titanium sheet with 95 Ag-5 Al braze alloy. Attack of the core by the brazing alloy is obvious.



a. .1% Manganese added



b. .2% Manganese added

FIGURE 3

250X

Etch: 10% HNO_3 + 1% HF

C. P. titanium core brazed to RS 140 titanium skin with
95 Ag-5 Al + Mn braze alloy.



a. .3% Manganese added



b. .5% Manganese added

FIGURE 4

250X

Etch: 10% HNO_3 + 1% HF

C. P. titanium core brazed to RS 140 titanium skin with
95 Ag-5 Al + Mn braze alloy.



25 CX

Etch: 10% HNO₃ + 1% HF

FIGURE 5

C. P. titanium core brazed to RS 140 titanium skin with 95 Al-5 Mn braze alloy. It is evident that this braze alloy forms good fillets. An additional diffusion layer has formed in the core.